GEOLOGY IN THE SECONDARY SCHOOLS

In the report of the Committee of Ten it was proposed to introduce a more systematic study of geology in the secondary schools. This seems a wise suggestion, for there are few subjects from which more can be obtained both in the way of training and desirable information. Yet there are at present few important subjects that are less extensively taught, and few from which less is obtained.

Geology is a discussion of the changes that are at present in operation to modify the surface of the earth and the application of these principles to explain the changes of the past, and thus unravel the history of the earth. It calls to its aid all the other natural sciences, and geologists find it necessary to make use of the facts, principles, and theories discovered or propounded by other scientists. It is thus a large subject, and in training has a tendency to broaden the mind. The science deals with large things, and for its conception calls upon the human intellect to make use of principles beyond the limit of the mind to *thoroughly* comprehend. As astronomers have taught us to lay aside our measurement by feet and inches when considering the starry heavens, so geologists are attempting to teach that minutes and hours, and, indeed, even years, cannot be used in measuring the events in the history of the earth. Human experience is brief, but time and space are infinite.

The imagination is trained by a study of geology, for one must look about him and see the changes that are in progress on every hand, and, dropping for the moment the human time measure, conceive what has happened through ages of such change. Reason and logic are called into play and, in a measure, the science becomes a philosophy.

That there is very valuable information to be obtained goes almost without saying, for the subject deals with the very land upon which we live. Every hill and valley, every lake and

waterfall has its story to tell; and in the rocks we find the pages of our earth's history. The geological training adds to the pleasure of living, for, wherever one may find himself, he sees a bit of history telling something of the past. In the railway train the panorama, which becomes wearisome to the ordinary traveler, is an unending source of pleasure and information, and in the rambles among the hills and mountains the geologist finds an interest in addition to that of beautiful scenery and fresh air.

But it is only as a result of a rather thorough study of the subject that one obtains the full benefit of geology, along the lines above stated, although *any* study of the subject, no matter how slight, does something toward securing these benefits. There is, however, another side to the geological training which, to my mind, seems the most important of all, because it fills what is often a very serious gap in the training of the mind. This is observation, reasoning, and the drawing of conclusions based upon the observations and the validity of the reasoning. These habits are demanded of every one who would succeed in the world, and yet they are often entirely omitted from the training of the youth, and he is obliged to obtain the training as best he may when thrown upon the world to care for himself. Geology is not the only subject from which these things could be learned; but it is one of the easiest and one from which other desirable ends may be gained at the same time.

As ordinarily taught, not only in many of the secondary schools, but also in many colleges, geology consists in the study of a text-book more or less inaccurate. A series of facts, often very abstruse, are literally dumped into the pupil's mind, to be sifted if possible, but, in all probability, to remain an unassorted and confusing mass. The kind of material that the pupil is able to sift from this heap is shown in the two answers (which were only a little worse than a number of others) recently given by two different pupils at a college-entrance examination. One said that a volcano is a "hole in the ground out of which pours fire, smoke, and ashes," and another, that a glacier is "a frozen mountain river which rushes down the mountain side with great velocity." Anyone familiar with the subject will see that the

students in question had been told something, but had not grasped the correct idea. The usual comparison of a glacier to a river of ice, and the memory of some statement about snow slides and avalanches have both found their place in the second definition, though very much out of place.

To secure the best results geology should be studied by the student in three schools — the grammar school, the high school, and the college. Properly, the teaching in the latter should be of a somewhat advanced character; but, unfortunately, at present it must be begun in a most elementary course, and the student leaves the first course with only the barest outline of first principles, ending with a knowledge of the subject equal only to that which he should have brought to the college.

The subject of geology could be made a most attractive addition to the grammar-school course of studies without taking a large amount of time; and the student could be thus prepared to begin the real *study* of the subject in the high school. Any new subject is difficult to master if every point is new. Many will remember their dismay when, upon entering the high school, they found that arithmetic did not enter largely into higher mathematics, but that numbers are actually replaced by letters. It often dazes the mind so that by the time one begins to realize the point, the course is so far advanced that he is barely able to keep up with the class. Had we been given a few elementary lessons in algebra along with arithmetic, these difficulties would not have been encountered.

So in geology; if in connection with geography, let us say, a few lessons be devoted to the earth's history, the mind would be prepared for future study. It would be dangerous to introduce too much; but it could be shown that the history of the earth is long and complex, that some of its pages have been deciphered, that animals and plants have progressively developed toward a higher state, and that the earth's history is divided into periods or chapters by means of a study of the entombed remains of former organisms, or fossils. The pupil could be told briefly of some of the changes that are at present in operation in the river, or lake, or sea; that these same changes are

incessant, and that in the course of long periods of time their effects are great and important. Technicalities should be omitted and dry details avoided, while merely the principles are impressed upon the mind.

Local illustrations should be used and a beginning made in observation methods. Five or six of the commonest minerals, which make up the bulk of the earth's crust, should be placed in every pupil's hands to observe and describe the characteristics. These should be followed by a few of the common rocks, such as conglomerate, sandstone, shale, limestone, marble, schist, gneiss, granite, diabase, and some lava. All of the distinguishing characteristics should be noted, and, in a few words, the pupil should be told how the rocks are formed. A few photographs, —or, better still, —models could be introduced to illustrate the larger phenomena, the Colorado cañon, Niagara, a river floodplain or delta, a rocky coast, a beach, a mountain, folded rock, a volcano, and perhaps others. By these means a body of fact will be given the pupil in such a way as to insure its assimilation, and at the same time some training in observation will be given. The amount should not be great, and the success of the plan would depend upon the teacher's tact in presentation. Most of the work could be woven in as a part of geography and in different places, some as home geography, the volcano when studying Italy, the floodplain when studying the Mississippi, etc.

Just where in the high school the subject of geology should be taught is a question of some difficulty and will need to be settled differently, according to the conditions in the schools. In any event, some of it should come in a term when field work is possible. While a text-book is necessary, the study of this ought to be the least important part of the work. Principles and methods should be given precedence, and the array of bare fact and (to the beginner) the meaningless and dry details should be introduced only where necessary, and then in such a way as to make it certain that they are understood. To know that reptiles became very important in the Jura-Trias period, and that they were abundant and varied in form, are important facts; but to know that there were such animals as Ichthyosaurus,

Plesiosaurus, etc., might better be left for later studies. It would be difficult to state in a short paper exactly what is important and what unimportant; and, in the present state of text-books, this must be left to the judgment of the teacher. The principle that should guide is to omit that part which merely trains the memory, for this side of the training of the mind is necessarily strongly brought out in other subjects, while geology is capable of giving another kind of training, provided the pupil is not confused, and his energies absorbed, in the task of memorizing a series of more or less disconnected and uninteresting facts.

Hand in hand with the text-book work, and as a more important part of the course, should come a study of specimens, models, photographs, and field phenomena. A collection of common minerals and rocks, and of specimens illustrating geological phenomena, should be studied by each student; careful observation should be demanded, and the pupil should be called upon to draw conclusions from his observation. In my own experience I find that the average student does not know how to observe, and that his conclusions are guesses rather than logical deductions. This can be discouraged by making the pupil state every step leading to his conclusion. To illustrate, let us suppose he has two specimens, one of conglomerate and one of a lava, with porphyritic crystals, the task being to tell how they can be distinguished. In the majority of cases the student will say "by the form" or "by the color." If he is made to describe each specimen carefully and not allowed to skip any important point, after a little time he sees a very marked difference; and, once having made a beginning, the habit of observation grows more keen. Or, to take another case, give him a conglomerate in which there is much feldspar, and ask him its origin. To answer this he must notice that there is much feldspar, and he must remember that feldspar is easily decayed and not mechanically strong. Therefore it could not have been washed about for a long time on the beach, and probably represents a product of disintegration in some protected bay. A piece of shale tells him that when formed the water was quiet,

and a conglomerate that the water was in rapid movement, as on a beach. These are very simple illustrations and very small points, but nearly every specimen can be made to tell a story, to train the power of observation, and to teach the method of arriving at logical conclusions. The subject then becomes more interesting, for a rock then becomes an objcct not to be remembered as being composed of this or that; but, instead, the student sees that, since it is so made, it has had a certain history.

Nothing is more valuable in geological teaching than abundant illustration. The chemist illustrates his lectures by experiments, and the student is himself made to conduct experiments to prove the points he learns. The same methods should prevail in geology; but most of the phenomena of geology are too large to introduce into the class room, and models, diagrams, and photographs must be substituted. These can be used for study by the individual student and as class illustrations. If possible, lantern slides should also be used, for they can be seen by all the class, and geological facts are thus made clear.

Finally, geological excursions should be made. There are few places which do not have some illustrations of geological facts and principles, and one field excursion is worth a dozen memorized lessons. In such work the student should be taught to observe for himself and to show the teacher what is illustrated rather than be told this by the teacher. Unless this is done much of the value of field work is lost. Another method, a nd one that is adopted with success in at least one high school in New York state, is to send out groups of students to make observations upon which they are to report.

It is difficult to offer suggestions in the matter of geological instruction, because conditions differ so greatly in different schools. There is an *ideal* which could be formulated with some ease, but at present it would be impossible in most schools. The teaching of geology is probably in a more imperfect state than that of any other science, and it will take time to develop it properly; but I believe that it should be developed, and, indeed, that it will be, because it is a subject that has merits

peculiar to itself. One aid to the development of proper teaching of geology must be its recognition by the college among its entrance requirements; and some institutions, among which, I am happy to say, is included the one in which I teach, have already offered such recognition.

Nothing has been said about one very important point, namely, the lack of properly trained teachers. Since few schools demand a high grade of work from teachers of geology, many students planning to teach science leave the colleges either with no knowledge of the subject of geology or else with a mere smattering, much less, indeed, than they should teach to their pupils. This is partly the fault of colleges, but largely the fault of the secondary schools. I would not place any of the blame upon the science teacher. Surely enough is demanded of him; but if the school principal considers a subject worth teaching, he should see that the teacher at least has some knowledge of the subject. Better omit one or two sciences than to have them mistaught.

The subject of geology, therefore, takes an inferior position because it is not properly taught, but is made into a mere text-book study, and often not from a very good text-book, from which a lot of miscellaneous information is obtained for the satisfaction of the curiosity, and a superabundance of dry facts is given by a teacher who often only obscurely appreciates them himself. As a result, what by ample experience has been proved to attract, interest and stimulate boys and girls and train their minds in important ways, is really made repulsive, uninteresting and often present the subject as it should be presented. If geology could be taught as it should be, it would, upon its own merits, create for itself a place in the curriculum, and one that would be recognized as filling a gap in education that few subjects are so well adapted to fill.

RALPH S. TARR

CORNELL UNIVERSITY,
Ithaca, N.Y.